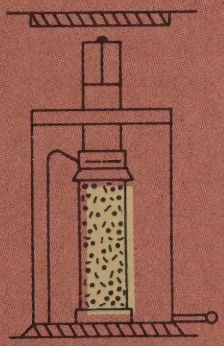
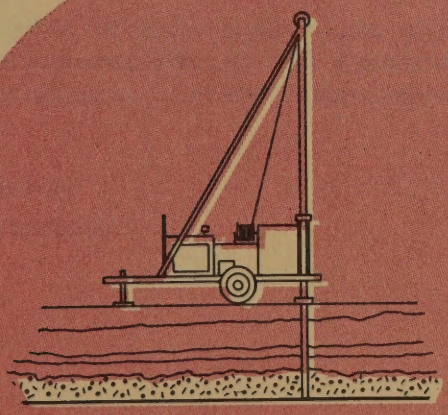
STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION

RAYMOND T. SCHULER, COMMISSIONER

SOIL MECHANICS
BUREAU





ROCK SLOPE STABILIZATION

SOUTHERN EXTENSION OF HALLENBECK ROAD

CITY OF PEEKSKILL - WESTCHESTER COUNTY

OCTOBER, 1975

SM 238b (1/73)

MEMORANDUM
DEPARTMENT OF TRANSPORTATION

DATE November 24, 1975

SUBJECT ROCK SLOPE STABILIZATION
SOUTHERN EXTENSION OF HALLENBECK ROAD
CITY OF PEEKSKILL - WESTCHESTER COUNTY

FROM Lyndon H. Moore, Director, Soil Mechanics Bureau, Room 102, Bldg. 7

TO Albert E. Dickson, Regional Director of Transportation, Region 8

cc Wm. P. Hofmann, Technical Services Subdivision, Room 210, Bldg. 7A
Edward V. Hourigan, Structures Subdivision, 6th Floor, Bldg. 5

On April 10, 1975, Mr. E. Potts, City Engineer, City of Peekskill requested engineering assistance through the North Westchester County residency for stabilizing a rock cut slope adjacent to Hallenbeck Road. The Region office requested the Soil Mechanics Bureau to investigate the problem area. The attached report was prepared by Clayton L. Bolton, Senior Engineering Geologist of this Bureau. Four additional copies of the report are submitted for transmittal to the North Westchester County residency and Mr. E. Potts, and any other interested parties.

The request for assistance by Mr. Potts was initiated by a rockslide about 30 feet in length that covered Hallenbeck Road located at the base of the rock cut. The main line tracks of the Penn Central are adjacent to Hallenbeck Road and 20 feet from the rock face. Inspection of the site indicated the rock cut is about 500 feet long, 45 feet high and nearly vertical. Besides the remaining unstable rock in the slide area, the entire 500 foot length contains critical rock conditions that could result in future rockslides that not only would fall on Hallenbeck Road but also cover the railroad tracks. Because of this serious safety consideration a detailed geologic investigation was made of the entire rock cut. We will be pleased to discuss this report in more detail with members of your staff.

Copies of this report are also being sent to Mr. E. V. Hourigan, Structures Design and Construction Subdivision, designated as the Department liaison organization with railroads on engineering problems.

LHM:MR
Attachment

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50 Wolf Road, POD 34
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ROCK SLOPE STABILIZATION

SOUTHERN EXTENSION OF HALLENBECK ROAD

CITY OF PEEKSKILL - WESTCHESTER COUNTY

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MEMORANDUM
DEPARTMENT OF TRANSPORTATION

DATE October 1, 1975

SUBJECT ROCK SLOPE STABILIZATION
SOUTHERN EXTENSION OF HALLENBECK ROAD
CITY OF PEEKSKILL, WESTCHESTER COUNTY

FROM Clayton L. Bolton, Senior Engineering Geologist

TO Lyndon H. Moore, Director, Soil Mechanics Bureau

INTRODUCTION

On April 2, 1975, a rockslide covered the southern extension of Hallenbeck Road in the City of Peekskill, New York. The slide occurred at the north end of a 500 foot long portion of the roadway where Hallenbeck Road and twin Penn-Central mainline tracks are confined in a 50 foot wide section by a 40 foot high vertical rock face to the east and by the shoreline of the Hudson River to the west. In retrospect, it was most fortunate that the slide debris was limited to the roadway since only one stone of the size contained in the rockfall would have been sufficient to cause derailment of a commuter train. Derailment at this location could force the train into the river.

The most serious problems which resulted from the slide was the temporary loss of electrical power, telephone service and access for the dozen or so families who reside between the slide area and the end of Hallenbeck Road to the north.

On April 10, 1975, Mr. E. Potts, City Engineer, City of Peekskill; Mr. K. Fuller, Assistant Resident Engineer, North Westchester County Residency and Mr. F. Zimmer of the Region 8 Soils Office met with representatives from this Bureau at the slide site. The purpose of the meeting was to examine the slide site to determine what steps should be taken to stabilize the rock slope.

The slide site is 30 feet in length, however the entire 500 feet of rock slope exhibits structures conducive to imminent rock slope failures. It was determined that an in-depth study should be made of the rock section to determine the best method of correcting the situation. The study was performed during the ensuing months with the assistance of Region 8 Soils' personnel. The study included a survey of the area which is shown by a plan sheet of the site (Drawing No. 1) and representative cross sections (Drawing No. 2).

The following report contains a description of the rock slope problem encountered and the recommended solutions to the problem.

THE PROBLEM

The instability of the rock slope along the southern extension of Hallenbeck Road is due to two causes. The first is a series of natural fractures and joints in the rock. Some of these dip steeply toward the road and railroad. The second cause was the blasting procedures used during the original

construction. At the time of the original construction, modern blasting methods (including presplitting and millisecond delay caps) were unknown. The rock was heavily loaded and all holes fired at once. Powder gases opened up and enlarged the natural fractures. Incomplete scaling operations resulted in unstable rock being left on the slope. In the ensuing years these fractures have been further opened by ice wedging, frost action, weathering and the wedging action of growing roots. These actions continue today. A complete discussion regarding rock joints and fractures in the subject cut may be found in Appendix F.

The rockfall which occurred on April 2, had a length of approximately 30 feet. Overlying rock in this section remains unstable. It is the writer's opinion that not only this section but the entire rock cut needs remedial treatment. Much larger slides can possibly occur.

The possible ramifications of future slides in the subject area are numerous and some could involve the loss of human life. Rockfalls can be triggered by ground vibrations such as those generated by a passing train. Lengthy disruption of rail service could occur due to track damage and/or the cleanup of fall rock. Even a small fall could put pieces of rock on the track large enough to cause derailment of an oncoming train.

The problems associated with the City road should also be considered. This road directly below the unstable rock slope is heavily used by children, fishermen and other pedestrians. It is also used by motor vehicles (including school buses) serving approximately twelve residences. Any rockfall in this area would definitely curtail for some time passage on this dead end road. A larger slide could easily interrupt power and telephone service, not only for the local residents but for other areas as well.

The following two stabilization solutions are submitted to correct this dangerous condition.

THE SOLUTION - ROCK SLOPE TREATMENTS

Two methods of correcting the unstable rock slope are presented. The first and most positive method consists of presplitting and flattening the rock slope to establish a permanently stable slope condition. The flatter slope should be constructed on a two vertical on one horizontal (63°) batter to coincide with natural fractures in the rock (see Drawing No. 2). The utilization of this method would eliminate the need for additional stabilization treatment and remove the danger of further rockfalls. The second method consists of a combination of six different remedial treatments to be applied to the existing rock slope. The remedial treatments are described later in this report.

PREPARATORY WORK

Before any remedial rock slope treatment can be performed, the site must be cleared and free for continuing operations until the selected stabilization

treatment is completed. Since the roadway must be closed, a new access road for the residents north of the project site must be constructed. This can be accomplished by reopening the access route through the sanitary landfill to the north of the involved residences.

The rock slope must be accessible to the workmen. This type of work is sufficiently difficult in its own right without the presence of additional hazards such as electrical power lines. It is mandatory that the local electrical and telephone lines situated along the east side of Hallenbeck Road be relocated for the duration of the project regardless of the stabilization method chosen. If Method I is selected, the railroad telephone and telegraph lines situated between the railroad and the roadway must also be relocated. The nearness of the utility lines to the work area is best illustrated by Figure No. 11, Page No. 18. A minimum time period of one month should be allotted for utility relocation and detour construction prior to implementing the rock slope stabilization procedure. It is estimated that the slope stabilization work for either Method I or II will require an additional two months time.

METHOD I

This method has the distinct advantage of establishing a permanently stable, aesthetic quality rock slope. The construction of such a slope is achieved by presplitting. Presplitting, basically defined, is the establishment of a shear plane in rock by the controlled usage of explosives in appropriately aligned and spaced drill holes. The basic advantage of presplitting is that it creates a crack to allow the escape of explosive gases without causing damage to the rock behind the final slope. A presplitting specification is included in Appendix A. This specification can be altered to allow the use of equipment available to the contractor.

The construction of a two vertical on one horizontal presplit slope would entail the removal of approximately 7,500 cubic yards of rock.

This method of rock slope treatment has two main disadvantages. The first disadvantage would be the stoppage of rail service for an uncertain period of time. The length of time would depend upon such matters as the blasting sequence selected; the type of track protection required; the use of blasting mats; and the coordination of blasting operations with rail traffic scheduling. Possibly, blasting operations could be performed at night to reduce disruption of rail traffic. The second disadvantage is that this method would undoubtedly be more costly than Method II. Method I would require that the work be performed by a contractor experienced in controlled blasting.

A detailed cost analysis of Method I would depend on discussions with the railroad as to scheduling operations and what precautions they would require for rail protection.

METHOD II

This method of stabilizing the rock slope consists of utilizing a combination of six types of stabilization procedures. Photographs of the problem areas are included in this report to illustrate the type and locations of the recommended remedial treatment.

The main advantage of Method II is the cheaper cost due to the possibility of performance of the work by agency maintenance forces rather than at contract prices. Another advantage is that no disruption in rail traffic is anticipated.

The main disadvantage of Method II is that it is not as permanent as Method I. Another disadvantage of Method II is one of aesthetics in that the slope would retain its ragged appearance.

Information on equipment requirements; cost of materials; and contract item cost estimates for Method II are included in Appendices B, C and D.

The six types of remedial rock slope treatment are described as follows:

REMEDIAL ROCK SLOPE TREATMENT METHOD NO. II

TYPE NO. 1 - SCALING

(Location: Baseline Stations 0 + 25± to 1 + 00± and 2 + 75± to 5 + 00±) The scaling operation shall consist of removing all loose rock and other unstable material from the rock slope. This shall be accomplished by hand labor, utilizing prybars and other hand held devices capable of removing the loose rock. Access to the loose rock on the slope can best be provided for by a man cage suspended from a crane. Care shall be taken to insure that loose rock scaled from the slope does not reach the railroad tracks. This hazard may be reduced by constructing a sand berm along the west side of the highway. "Scaling Specification - Page 21."

TYPE NO. 2 - PNEUMATICALLY PROJECTED CONCRETE

(Location: Baseline Station 0 + 60±. Left)
The April 2, 1975 slide area remains unstable. The rock in back of the removed slide material is perched precariously thirty feet up on the rock face. Since it would be extremely dangerous to drill and bolt this rock mass in place without initial support, it is recommended that the slide area be thoroughly scaled by means of high pressure water. The area shall then be supported by several applications of pneumatically projected concrete until the grout has achieved a thickness of approximately 18 inches along the hinge lines (designated by two long and one short dash lines on Figure No. 1, Page No. 10). The area to be stabilized with pneumatically projected concrete is delineated by short dash lines on Figure No. 1. For Pneumatically Projected Concrete Specification see Page No. 22.

TYPE NO. 3 - ROCK BOLTING

The bolt locations and the corresponding drill hole depths are marked on Figures No. 1, 2, 4, 6, 7, 9 and 10 of this report. Please note that in all cases, the length of the rock bolt to be placed shall be six inches shorter than the corresponding drill hole depth. In summation, it will require 306 feet 6 inches of rock bolts to complete stabilization of the rock slope area (33 bolts 4 feet 6 inches in length; ten bolts 9 feet 6 inches in length; three bolts 14 feet 6 inches in length and one bolt 19 feet 6 inches in length).

For Rock Bolt Specification see Page No. 24.

Rock bolts are obtainable from Bethlehem Steel; Republic Steel and Williams Form Engineering Company. Delivery of rock bolt orders usually requires six weeks.

TYPE NO. 4 - STEEL STRAPPING

Steel straps are required at various locations as are indicated on Figures No. 1, 4 and 6 of this report. Straps reduce the number of rock bolts required to stabilize a rock slope of this type. Straps as applied to this area have two distinct advantages: 1) unstable rock masses which cannot be stabilized by rock bolts alone are safely retained, and 2) they enable support of overhanging rock masses which if supported by rock bolts would present an extreme hazard to the workmen during installation. It is estimated that 100 linear feet of steel strapping (five straps 20 feet in length) will be required to complete this work. For Steel Strapping Specification, see Page No. 26.

TYPE NO. 5 - CYCLOPEAN CONCRETE

The stabilization of the hanging wall rock mass depicted in Figure No. 8, Page No. 16 of this report can be supported by a reinforced concrete wall or by reinforced concrete columns. Due to the high cost of structural concrete and the hazard involved in working in this area, it is recommended that forms be constructed along the three walls outlined in black on the photograph and the entire void filled with concrete. It is estimated that 150 cubic yards of concrete will be required to perform this operation. The quantity of concrete necessary could be reduced by 50 percent by utilizing the large pieces of rock removed during the scaling operations and from the stockpile of slide material adjacent to the problem area. This rock is of excellent quality and would not reduce the strength of the supporting concrete. Concrete containing large boulders of this type is known commonly as Cyclopean Concrete.

The dirt area under this overhang should be removed (preferably by high pressure water) to expose the bedrock on which to support the concrete pour.

It is further recommended that the pour be conducted in four stages with the first stage constructed to a height of three feet above the present roadway grade, the second stage four feet in height, the third stage five feet in height and the fourth final stage capping the support with a six foot high pour in the top wedge shaped area. No rock larger than six inches in diameter should be utilized in the final pour stage.

The estimated quantities of concrete and stone required to perform this work on the basis of stages is as follows:

Stage No.	Concrete	Rock	Total
1	21 c.y.	21 c.y.	42 c.y.
2	24 c.y.	23.5 c.y.	47.5 c.y.
3	22 c.y.	20.5 c.y.	42.5 c.y.
4	10 c.y.	8 c.y.	18 c.y.
Totals	77 c.y.	73 c.y.	150 c.y.

TYPE NO. 6 - GROUTED EYEBOLT AND CABLE TIE BACK

This type of stabilization method is utilized in anchoring large boulders when removal by scaling is considered unfeasible. A boulder measuring six feet by six feet by ten feet is balanced precariously above the roadway at the edge of a badly weathered rock zone at Baseline Station 2 + 02±, left. (See Figure No. 3, Page No. 12.)

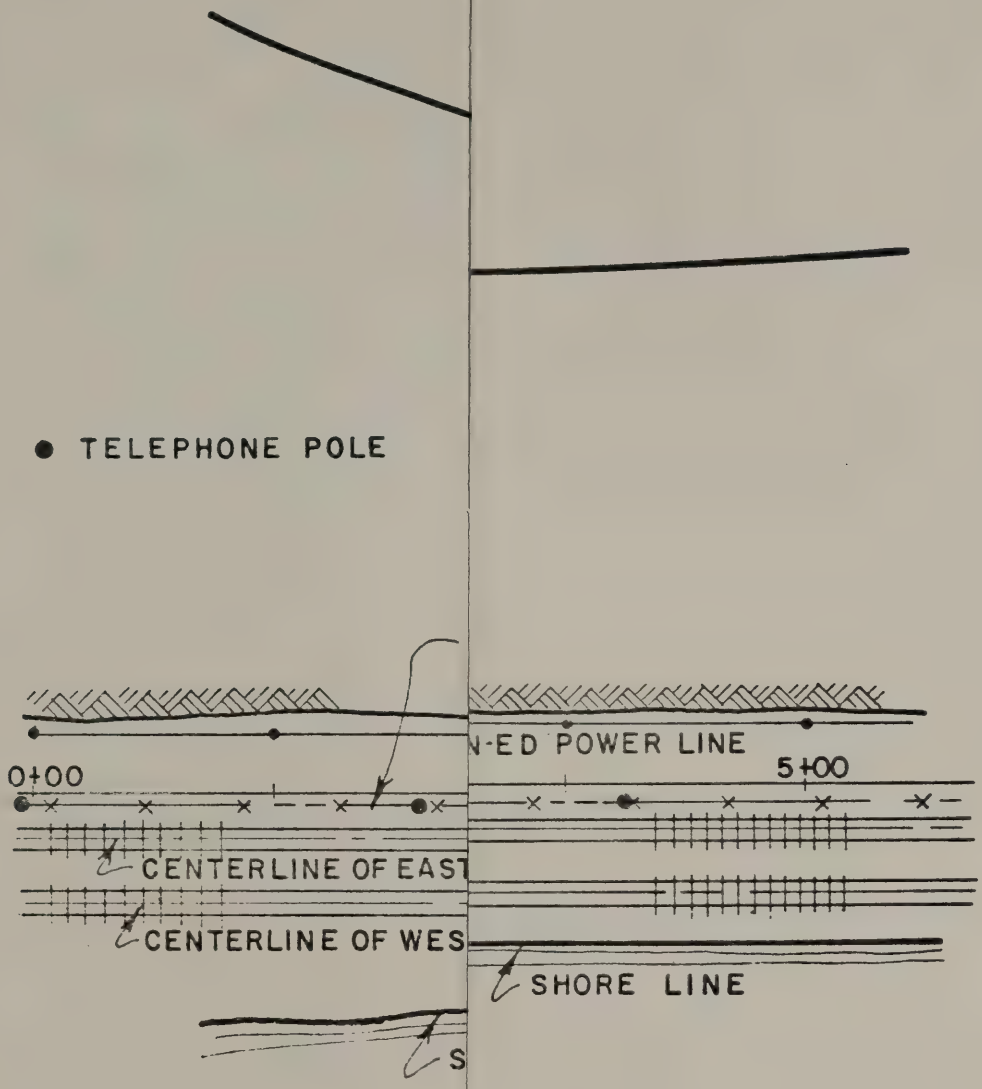
This method consists of grouting a No. 6 eyebolt three feet into the top center of the rock approximately three feet in back of the front face of the boulder. A second No. 6 eyebolt shall be grouted into sound bedrock approximately 15 feet in back of the boulder.

To complete this operation, a 25 foot long Steel Strand Cable, three quarters of an inch in diameter will be required to connect the installed eyebolts. A minimum of one foot of cable overlap at each eyebolt is required. The overlap shall be fastened at each end of connecting cable by means of two-three quarter inch bolted cable clamps.

An alternate method for stabilizing this boulder area would be to drill and blast the rock or to utilize the drop ball method to break the rock into manageable size pieces which can be scaled and removed.

No specification is provided for this type of stabilization.

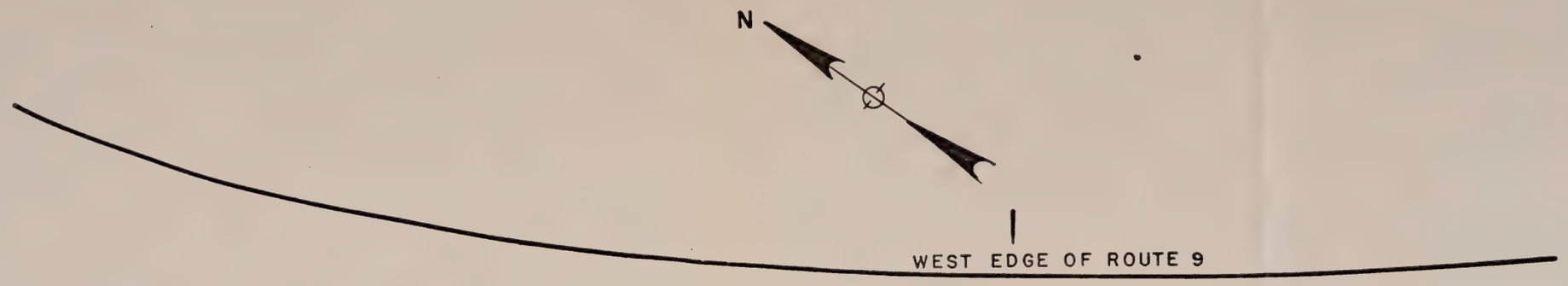
CLB:BR



STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
DIVISION OF DESIGN AND CONSTRUCTION
ROCK SLOPE STABILIZATION
SOUTHERN EXTENSION OF HALLENBECK ROAD
CITY OF PEEKSKILL

PLAN OF AREA

DRAWING 1 OF 2



● TELEPHONE POLE

A B

BROKEN PENN CENTRAL FENCE LINE AND TELEGRAPH POLE LINE

TOE OF ROCK FACE

SOUTH EXTENSION HALLENBECK ROAD

CON-ED POWER LINE

0+00 1+00 2+00 3+00 BASELINE 4+00 5+00

CENTERLINE OF EAST TRACK

PENN CENTRAL RAILROAD

CENTERLINE OF WEST TRACK

SHORE LINE

SHORE LINE

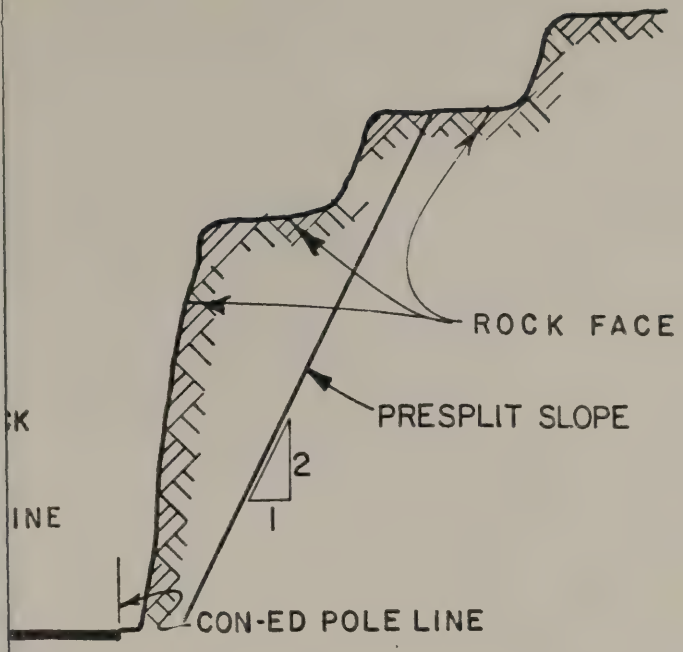
HUDSON RIVER

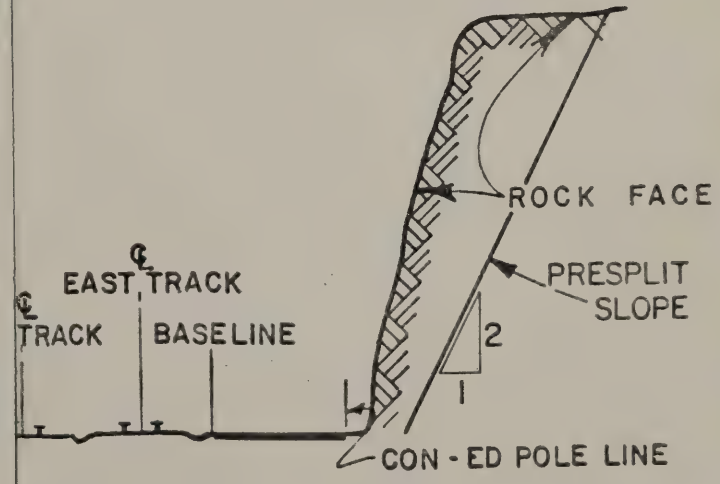
PLAN
SCALE: 1"= 40'

A B

REGION NO. 8
COUNTY: Westchester
DWG. NO. 8 SM 2071A

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
DIVISION OF DESIGN AND CONSTRUCTION
ROCK SLOPE STABILIZATION
SOUTHERN EXTENSION OF HALLENBECK ROAD
CITY OF PEEKSKILL
PLAN OF AREA
DRAWING 1 OF 2





STATE OF NEW YORK
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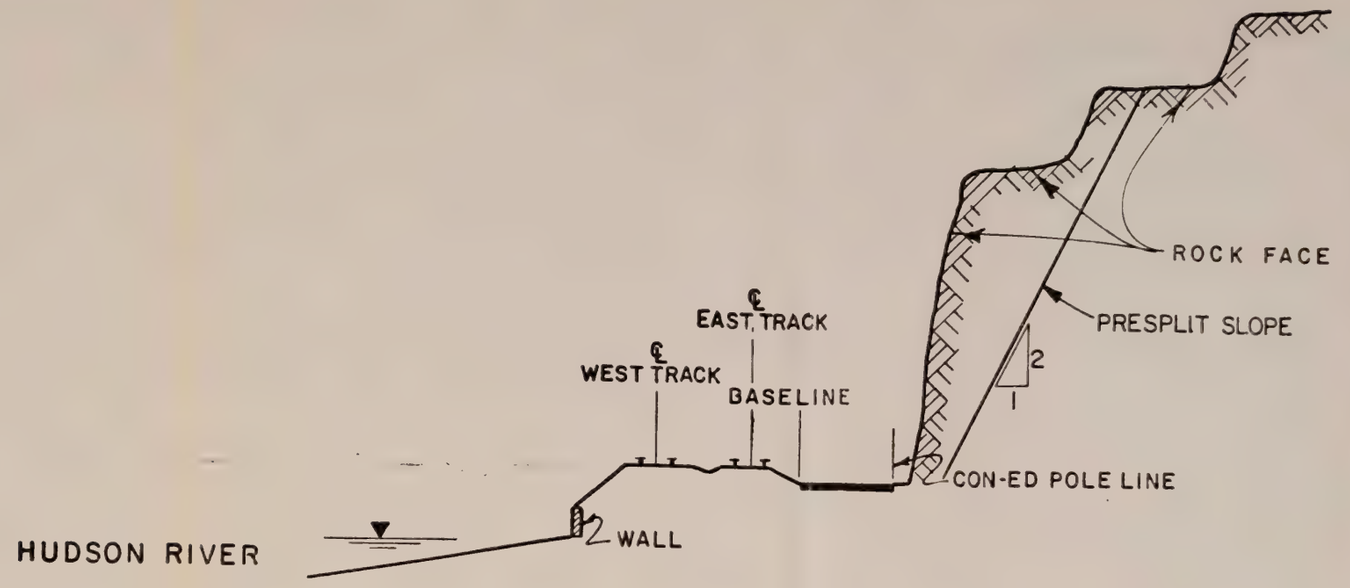
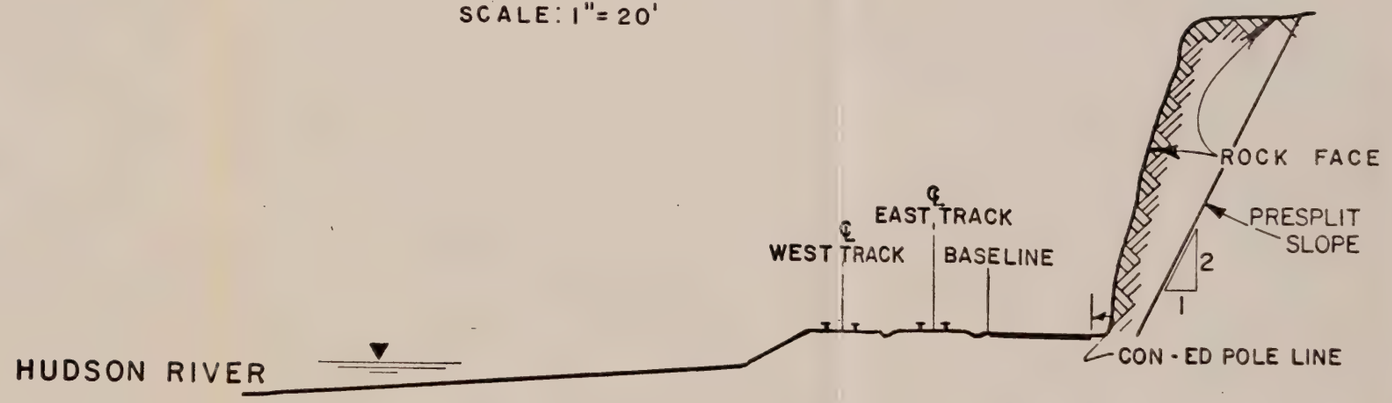
ROCK SLOPE STABILIZATION
SOUTHERN EXTENSION OF HALLENBECK ROAD
CITY OF PEEKSKILL
CROSS SECTIONS
DRAWING 2 OF 2

hester
20718



SECTION B-B
SCALE: 1"= 20'



SECTION A-A TYPICAL
FROM
℄ STA. 0+00 TO ℄ STA. 3+50
SCALE: 1"= 20'

REGION NO. 8
COUNTY: Westchester
DWG. NO. 8 SM 20718

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
DIVISION OF DESIGN AND CONSTRUCTION
ROCK SLOPE STABILIZATION
SOUTHERN EXTENSION OF HALLENBECK ROAD
CITY OF PEEKSKILL
CROSS SECTIONS
DRAWING 2 OF 2

Figure No. 1-Baseline Station 0+60±, left.

I - Pneumatically projected concrete designated by dashed outline.
II - Double hingelines to be built up to an 18 inch thickness. The hingelines are designated by two long lines separated by a short dash line.
III - Bolt locations are designated by hole depth
IV - Steel straps connecting bolts are designated by solid lines.

Rock Bolts Required

3 bolts@4'-6" = 13'-6"
2 bolts @ 9'-6" = 19'-0"
1 bolt @ 19'-6" = 19'-6"
Total = 52'-0"

Strapping Required

30 L.F.

Construction Sequence

I - Scale shotcrete area with high pressure water.
II - Apply pneumatically projected concrete (shotcrete).
III - Place bolts and straps in the following sequence:

1 - 10 foot - upper left.
2 - 5 foot - lower left
3 - Strap 1 to 2
4 - 20 foot - upper right
5 - 10 foot - upper center
6 - 5 foot - lower right
7 - Strap 4 to 6
8 - 5 foot - lower center
9 - Strap 5 to 8

Figure No. 2- Baseline Station 0+92±, left.

Rock Bolts

3 Bolts @ 9'-6" = 28'-6"
1 Bolt @ 4'-6" = 4'-6"

Total = 33'-0"

Construction Sequence

1 - 10 foot - upper right
2 - 10 foot - upper left.
3 - 10 foot - center left.
4 - 5 foot - lower left.

Figure No.3 - Baseline Station 2+02±, Left

Construction Sequence

1 - Install grouted No. 6 eyebolt, three feet into top center of rock, Three feet in back of front face of boulder.

2. - Install grouted No. 6 eyebolt into sound bedrock approximately 15 feet in back of the boulder.

Grout shall consist of neat cement grout using Type 3 Cement (High Early Strength). Cure for 5 days before cable installation.

3 - Install 3/4 inch diameter steel strand cable between eyebolts. A minimum of one foot of cable overlap is required.

4 - Attach cable through boulder eyebolt with two 3/4 inch bolted cable clamps.

5 - Using a cable tensioning device, pull cable through bedrock eyebolt until cable is taut.

6 - While cable is in tension, affix cable overlap to main cable with two 3/4 inch bolted cable clamps.

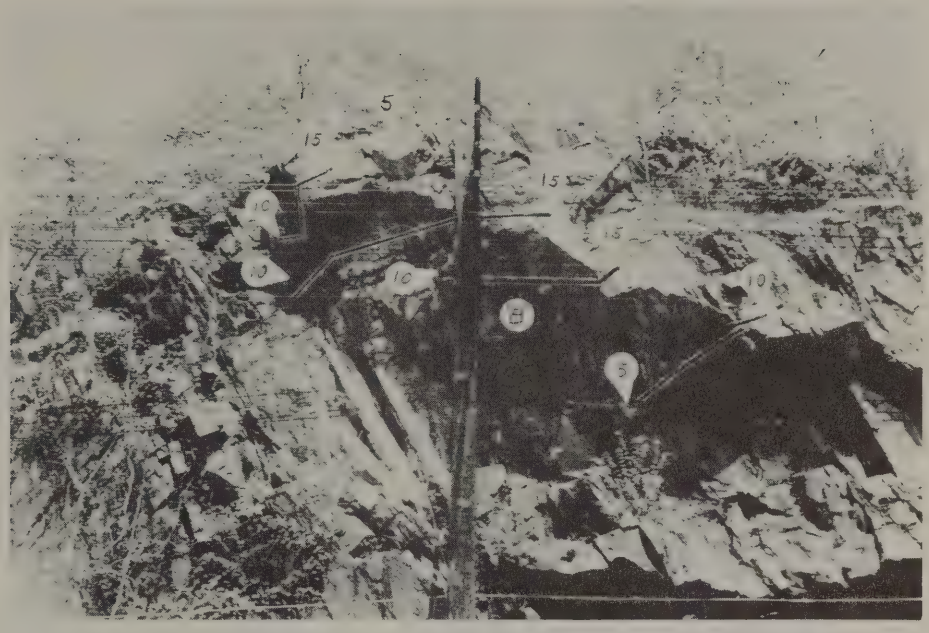


Figure No. 4 - Baseline Station 2+89±, to 3+30±, left.

Rock Bolts	Straps
3 Bolts @ 14'-6" = 43'-6"	50 L.F.
4 Bolts @ 9'-6" = 38'-0"	
2 Bolts @ 4'-6" = 9'-0"	
Total = 90'-6"	

Construction Sequence

1 - Install 5 foot bolts, upper left Figure No. 6.
2 - 5 foot - top center.
3 - 15 " - upper left.
4 - 10 " - " " .
5 - Strap 3 to 4 .
6 - 15 foot - top center.
7 - 10 " - bottom left.
8 - Strap 6 to 7
9 - 15 foot - top right.
10 - 10 " - bottom center.
11 - Strap 9-10
12 - 10 foot far right.
13 - 5 foot bottom right.
14 - Strap 12 to 13.

Figure No. 5 - Baseline Station 2+89± to 3+30±, left.

Overhead view of same location depicted by figure No. 4.
Note overhang.

Inked lines indicate proposed Strap locations.

Letter "B" indicates upper surface of Joint Set No. 2.

Letter "E" indicates fine tension joints or blasting fractures.

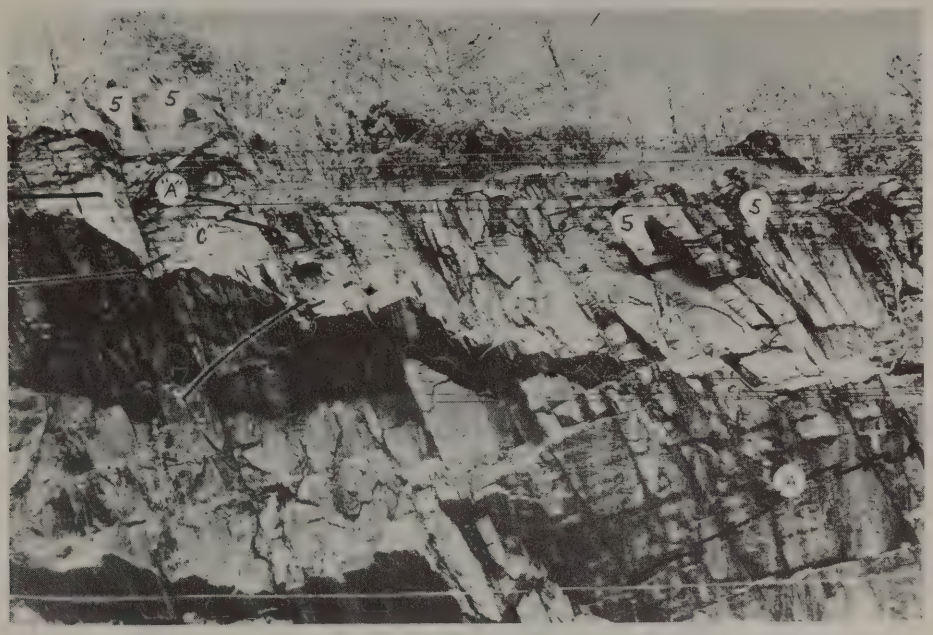


Figure No. 6 - Baseline Station 3+25± to 3+75±, left.

Bolts Required

4 bolts @ 4'-6" = 18' -0" Total

Strap Required

1 Strap at 15 L F

Letter "A" designates Joint Set No. 1

Letter "C" designates bottom surface of Joint Set No. 3

Construction Sequence

Five foot bolts in upper left are to be installed before commencing work designated on Figure No. 4

Figure No. 7 - Baseline Station 3+56+, left.
Rock Bolts - 6 bolts @ 4'-6" = 27'-0" Total
Install top bolts first.

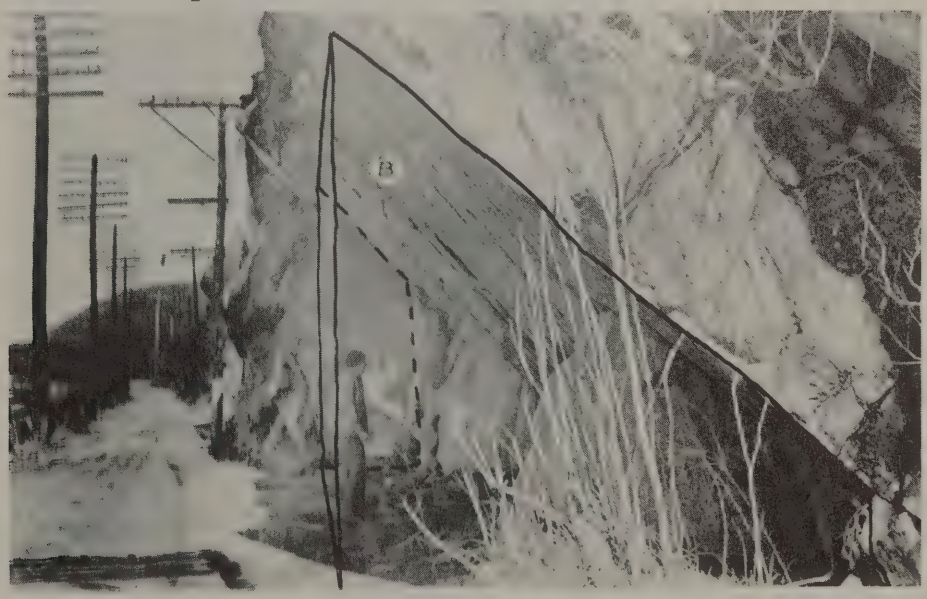


Figure No. 8 - Baseline Station 3+60+, left.
Area outlined in black shall be formed and filled in four stages with Cyclopean Concrete .
Letter "B" designates upper surface of Joint Set No. 2

Figure No. 9. - Baseline Station 3+87+, left.
Rock Bolts - (2 @ 4'-6" = 9"-0" + 1 @ 9'-6" = 18'-6" Total)
Install top bolts first.

Figure No. 10 - Baseline Station 4+93+, left.
Rock Bolts - 15 @ 4'-6" = 67'-6" Total
Install top bolts first and continue toward bottom.
Letter "D" designates Joint Set No. 4

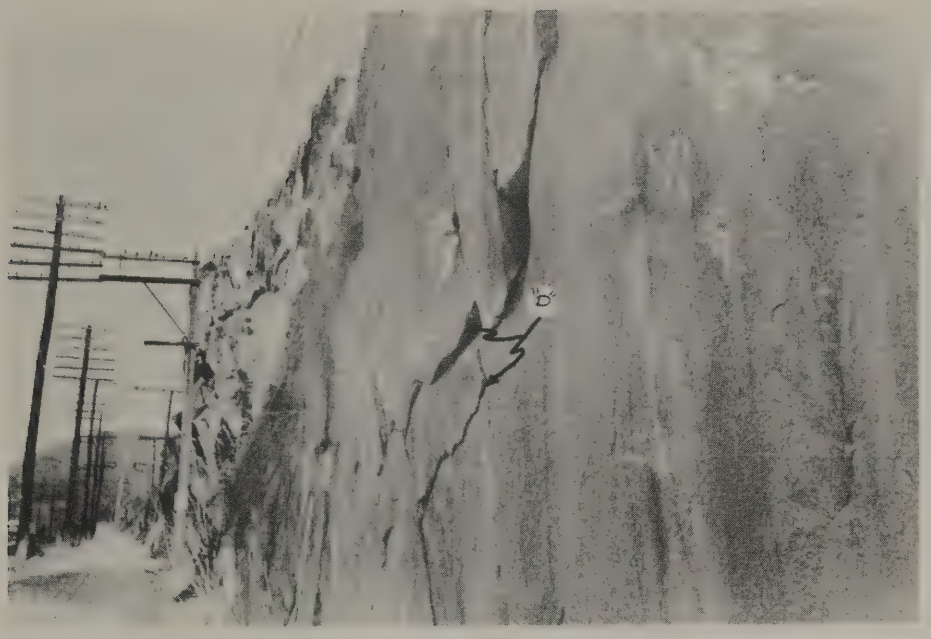


Figure No. 11 - Baseline Station 4+93±, looking North.

Same Subject as depicted by Figure No. 10.
This photo taken to illustrate the steep angle of dip toward the roadway of these "feather" joints designated by the letter "D".

Note the nearness of the utility lines to the rock face.

APPENDIX A

SPECIAL SPECIFICATIONS (METHOD I)

PRESPLITTING

Presplitting is required where the design slope of a cut is one vertical on one horizontal or steeper and the slope distance exceeds five feet. Ripping will not be allowed within ten feet of a slope that requires presplitting. All rock slopes shall be thoroughly scaled to the satisfaction of the Engineer before fragmenting the next lift. In no case shall the subgrade be trimmed prior to the completion of the scaling operation at any location.

Finished rock slopes shall be stable and free from possible hazards of falling rock or rockslides that endanger public safety. If, after proper scaling, such hazards still exist, a determination of the cause will be made by a geologic study and if it is determined that the hazards are the result of poor workmanship or improper methods employed by the Contractor, he shall provide approved remedial treatment at no expense to the agency which let the contract. Such treatment may include, but is not necessarily limited to, laying back the slope, rock bolting or shotcreting.

A. Presplitting

Prior to drilling presplitting holes, the overburden shall be removed to expose the rock surface. The methods of collaring the holes to achieve proper inclination and alignment shall be approved by the Engineer.

The presplitting holes shall be a maximum of four inches in diameter, spaced not more than three feet center to center along the slope, and drilled at the design slope inclination for a maximum distance of 60 feet. When excavation operations are conducted in vertical lifts the presplitting holes for successive lifts may be offset a distance of not more than three feet for a design slope of one vertical on one horizontal and not more than one foot for slopes of steeper design; however a presplitting hole shall not be started inside the payment line. If presplitting is conducted in lifts, each lift shall be of approximately equal depth.

All presplitting holes shall be checked and cleared of obstructions immediately prior to loading any holes in a round. Presplitting holes shall be loaded with a continuous column charge manufactured especially for presplitting containing not more than 0.50 nor less than 0.15 pounds of explosive per foot. The charge near the top of the hole may be reduced to eliminate overbreak and heaving. The top of the charge shall be located not more than three feet below the top of rock. A bottom charge of not more than eight pounds of dynamite may be used; however no portion of any bottom charge shall be placed against a proposed finished slope. Each presplitting hole shall be filled with No. 1A crushed stone stemming material. The presplitting charges shall be fired with detonating fuse extended the full depth of each hole and attached to a trunk line at the surface. Detonation of the trunk line shall be with electric blasting cap(s) and shall precede the detonation of fragmentation charges within the section by a minimum of 25 milliseconds. Presplitting shall extend for a minimum distance equal to the burden plus three feet beyond the limits of fragmentation blasting within the section. Test sections will be required at the outset of presplit drilling and blasting operations for the evaluation of the presplit

rock slopes. The Contractor will be required to completely expose the presplit rock face in the test area for the evaluation.

B. Fragmentation Blasting

Fragmentation holes or portions thereof shall not be drilled closer than four feet to the proposed finished slope. When the design slope inclination is three vertical on two horizontal or steeper, the fragmentation holes adjacent to the presplitting holes shall be drilled in a plane parallel to the presplitting holes for the full depth of the production lift. Unpackaged water gels and/or slurries will not be permitted within 20 feet of the finished slope. Fragmentation charges shall be detonated by properly sequenced millisecond delay electric blasting caps.

APPENDIX A

SPECIAL SPECIFICATIONS (METHOD II)

REMOVAL OF HAZARDOUS ROCK AND DISPOSAL OF SPOIL

DESCRIPTION

Under this item the Contractor shall scale all loose rock and other material from the existing rock backslopes, within the limits shown on the plans or as ordered by the Engineer and remove and dispose of all spoil resulting from the scaling operation.

MATERIALS

None

CONSTRUCTION DETAILS

Scaling. The rock slopes shall be thoroughly scaled by means of a mechanical device designed to catch onto and pull all loose rock and other debris from the slopes. Rock which cannot be removed by mechanical means but which in the opinion of the Engineer constitutes a potential hazard, shall be removed by drilling and blasting. Upon completion of mechanical scaling and auxiliary drilling and blasting for scaling purposes, the slopes shall be scaled manually to remove any additional loose debris which cannot be removed by other means.

Protection of Pavement and Structures. The Contractor shall adequately protect the pavement in areas being scaled in a manner such that the pavement is not damaged by equipment or falling rock. The Contractor shall repair all damage to pavement and appurtenant structures resulting from his operations, as ordered by the Engineer.

METHOD OF MEASUREMENT

Spoil removed from the project shall be measured by the ton on portable scales provided by the State. Sufficient scales will be provided to weigh trucks up to ten wheels. Trucks having over ten wheels will not be permitted.

BASIS OF PAYMENT

The unit price bid per ton shall include the cost of furnishing all labor, materials, and equipment necessary to complete the work, (including any drilling and blasting required to scale rock from the slope and/or break-down large blocks of scaled rock to facilitate removal from the site). It shall also include the cost of protecting the pavement and appurtenant structures and any repairs required.

PNEUMATICALLY PROJECTED CONCRETE

DESCRIPTION

Under this item the Contractor shall place and cure pneumatically applied coatings of cement mortar on portions of the exposed rock surfaces of the roadway where directed. As a part of the work, the Contractor shall clean, by approved means, all rock surfaces as directed by the Engineer.

MATERIALS

Cement mortar placed under this item shall consist of Portland Cement Type 2, as specified in Materials Specification 701-01, and Concrete Sand, as specified in Materials Specification 703-07, mixed in the proportions herein specified. The same brand of cement from the same mill and the same source of aggregate shall be used throughout the whole of any application. Mixing water and water for curing shall conform to the requirements of Materials Specification 712-01.

Proportions. All pneumatically projected concrete shall be composed of approximately one part of Portland Cement Type 2 to three parts of sand. The proportion of sand may be varied from time to time as the volume of sand exceeds the volume of dry sand due to moisture. The sand shall be measured either by volume or weight in an approved proportioning plant or by means of approved batch boxes. Wheelbarrows or shovels will not be permitted for measuring.

Mixing. The Portland Cement and the Concrete Sand shall be thoroughly mixed dry in an approved mixer and placed under pneumatic pressure with a machine satisfactory to the Engineer. Mixer should be inspected and cleaned at least once a day (more often, if necessary) to prevent accumulations of batched material. Any mixed material standing more than one hour in the mixer shall be wasted.

Water. The water used in hydrating the material at the nozzle shall be maintained at a uniform pressure of 60 pounds per square inch or at a pressure greater than 15 pounds above the pressure of the air as used.

Application. The pressure in the lower chamber shall be that which will produce a nozzle velocity of 375 feet to 500 feet per second, where a tip with 3/4 inches or 1 inch opening is used, and of 425 feet to 550 feet per second, where a tip of 1-1/4 inch opening is used. Air must be maintained at a steady pressure. A suitable device shall be installed at the nozzle to indicate the velocity.

CONSTRUCTION DETAILS

Method. All surfaces to receive concrete coatings shall be wetted immediately prior to application. For applying the coatings, the Contractor shall provide apparatus of approved design which will apply the materials by means of pneumatic pressure. Facilities shall be provided for metering and controlling the addition of water to the sand and cement. Air shall be provided in sufficient volume and under such pressure as may

be necessary for the best operating conditions. In applying the cement mortar, the discharge nozzle shall be held so that the stream of material shall impinge, as nearly as possible, perpendicular to the surface being coated, and the velocity of discharge from the nozzle, the distance of the nozzle from the face and the amount of water used shall be regulated so as to produce a dense coating with the minimum rebound of material and no sloughing. Rebounding material shall not be used again, but shall be removed from the work and disposed of by the Contractor as a part of the work under this item. In general, cement mortar coatings shall have a thickness of not less than 1-1/2 inches except that a minimum thickness will be permitted on projecting points of rock, however, greater or lesser thickness may be ordered. Wherever a coating is to be applied upon one previously placed, sufficient time shall elapse between applications to insure that the material will not slough off. If an additional coating is ordered over a previously placed layer which has set, the surface of the first layer shall be cleaned by means of air and water jets before starting work.

Protection. The cement mortar applied under this item shall be cured either by keeping the concrete wet for at least seven days after placing or by application of a suitable curing compound approved by the Engineer. No concrete shall be applied when the temperature is below 40° F., or against surfaces in which there remains any frost. Concrete applied in cold weather shall be maintained at temperatures not less than 40° F. for seven days after placing. Concrete shall not be applied while it is raining.

METHOD OF MEASUREMENT

The quantity to be paid for under this item will be measured by the number of U.S. bags of Portland Cement required.

BASIS OF PAYMENT

The unit price bid per bag shall include the cost of furnishing all labor, materials and equipment necessary to complete the work.

ROCK BOLTING

DESCRIPTION

Under this item the Contractor shall furnish and install rock bolts and appurtenances at the locations shown on the plans or as directed by the Engineer.

MATERIALS

Rock bolts shall be of the expansion shell type consisting of a solid bar of high strength steel with a nominal diameter of three-quarters of an inch. The bolt lengths shall be as shown on the plans or as directed by the Engineer.

Malleable iron expansion shells shall be self-supporting and have a minimum length of three inches.

Flat or dished steel bearing plates, or approved equal, shall be a minimum of six inches square with a centrally punched hole of sufficient size to accommodate the bolt and appropriate washer. The flat and dished plates shall have a minimum thickness of three-eighths of an inch and one-quarter of an inch respectively.

Cast beveled or spherical washers shall be utilized as necessary to provide uniform bearing. Beveled washers shall be used with flat-bearing plates and spherical washers shall be used with dished bearing plates.

Washers shall have a minimum hardness of 35 measured on the Rockwell C scale and shall be a minimum of two inches in diameter and one-eighth inch thick. Hexagonal steel nuts shall be provided as required.

CONSTRUCTION DETAILS

Bolt hole(s) shall be one and five-eighth inches in diameter and shall be drilled into the rock face normal to the plane(s) of potential failure, or as directed by the Engineer, to a depth at least six inches greater than the length of the bolt being installed. From the rock face outward the bolt assembly shall consist of the bearing plate, the appropriate washer, the hardened washer and the bolt head or hexagonal nut. When headless bolts are supplied, the shell shall be placed so that the torquing end of the bolt extends no more than one inch beyond the required appurtenances after initial expansion and anchorage of the shell has been achieved. Lubrication shall be applied between the hardened washer and the bolt head or hexagonal nut. Torque shall be applied by use of an impact hammer or torque wrench to a value of 200 to 250 pounds. A blind hexagonal nut shall be used to expand the shell when headless bolts are supplied. The blind hexagonal nut shall be removed before applying final torque.

METHOD OF MEASUREMENT

Rock bolting shall be measured by the number of linear feet of rock bolts installed.

BASIS OF PAYMENT

The unit price bid per linear foot for this item shall include the cost of furnishing all equipment, materials, tools and labor necessary to complete the work.

STEEL STRAPPING

DESCRIPTION

Under this item the Contractor shall furnish and install steel strapping at the locations shown on the plans or as directed by the Engineer.

MATERIALS

Steel straps shall be of suitable length, six inches wide and one-quarter inch thick. Any open hearth, electric furnace or basic oxygen furnace steels suitable for punching and shearing may be used.

CONSTRUCTION DETAILS

The steel strap(s) shall be placed on the rock bolts against the rock surface and secured by washers and hexagonal nut(s) as otherwise specified.

The straps should span the distance between rock bolts and be deformed such that they follow the contour of the rock surface.

METHOD OF MEASUREMENT

Steel strapping shall be measured by the number of linear feet installed.

BASIS OF PAYMENT

The unit price bid per linear foot for this item shall include the cost of furnishing all equipment, materials, tools and labor necessary to complete the work.

APPENDIX B

ESTIMATED EQUIPMENT (METHOD II)

The list of equipment which is estimated to be the minimum required to complete the rock slope stabilization project is as follows:

Major Equipment

1 - Motor Crane with 90 Foot Boom
1 - Front End Loader
1 - Dump Truck
1 - Light Utility Truck (Pickup)
1 - Compressor (150 CFM - Minimum)
1 - Man Cage (6' x 8' Minimum)
1 - Concrete Mixer

Scaling Equipment

2 - Potato Hooks
2 - Crow Bars
2 - 1" Blow Pipes (10 L.F. ea.)
2 - Hand Shovels

Shotcreting Equipment

1 - Double chamber shotcreting gun
1 - Pressure Nozzle and 100 LF of Reinforced Hose
1 - 1000 Gallon Water Tank
1 - 2" Water Pump
100 LF of 2" Water Hose
1 - 2" High Pressure Water Nozzle
Measuring Bins

Rock Bolting Equipment

1 - Pneumatic Drill
Reinforced Air Hose (150 L.F.)
2 Each - Drill Steel (Lengths - 2', 4', 6', 8', 10', 12', 14', 16', 18' & 20')
1 - Sullivan Pin
2 - 3/4" Single - Sheave, Hooked, Wood Tackle Blocks
1 - 14" Pipe Wrench
1 - 18" Pipe Wrench
1 - Impact Wrench
1 - Torque Wrench
Manila Rope (100 LF of 1/2" Rope, 100 LF of 3/4" Rope)
1 - 1" Blow Pipe Extension (10 LF)
2 Each - Drill Bits (carbide inserts - 1-5/8", 1-3/4", 1-7/8" & 2")

Steel Strapping Equipment

1 - Acetylene cutting torch

APPENDIX C

ESTIMATED COST OF MATERIALS (METHOD II)

Item	Quantity	Unit	Unit Price	Total Price
Cement (For Shotcreting)	150	Bag	$ 2.30	$ 345.00
Rock Bolts (Includes all hardware)	306.5	L.F.	1.00	306.50
Steel Strapping	100	L.F.	1.20	120.00
Concrete	77	C.Y.	30.00	2,310.00
Drill Bits (Carbide Insert)	8	Each	25.00	200.00
Estimated Total Material Cost				$3,281.50

It is anticipated that any additional material and equipment required to complete the project is available to the concerned agency or can be provided by the Department of Transportation.

APPENDIX D

CONTRACT ITEM COST ESTIMATE (METHOD II)

Item	Quantity	Unit	Unit Price	Total Price
Scaling	25	Tons	$ 30.00	$ 750.00
Shotcrete	150	Bag	50.00	7,500.00
Rock Bolting	306.5	L.F.	35.00	10,727.50
Strapping	100	L.F.	7.00	700.00
Concrete	77	C.Y.	200.00	15,400.00
Grouted Eyebolt and Cable Tie Back	1	L.S.	150.00	150.00
Total Cost Estimate of Pertinent Items				$35,227.50

APPENDIX E

LOCAL GEOLOGY

The five hundred feet of rock face which comprises the entire problem area dealt with in this report is in essence the Southwestern terminus of the Reservoir granite and granite gneiss. The Reservoir granite includes a band of rock which extends northeast a distance of 27 miles to a point approximately two miles east of the Dutchess County hamlet of Poughquag. The Reservoir granite band follows a NE-SW trend achieving a maximum lateral extent of approximately four and one-half miles at Kent Cliffs in Putnam County.

The Reservoir granite as it was commonly known at the turn of the Century has since been combined with the Canada Hill granite and the Mahopac granite to form the "Canada Hill granite phase." The "Canada Hill granite phase" is one of the most widely distributed granites of the Hudson Highlands. The Canada Hill phase consists of a medium grained, medium gray biotite granite. The white and gray feldspars are primarily albite, oligoclase and perthite (Kurt Lowe, 1958) however, the pinkish cast of the rock in the problem area is due to the presence of the feldspars - (orthoclase and microcline). Gray quartz is an essential constituent and violet red to dull red garnet is an abundant accessory. Bands of biotite (dark mica) flakes present in the problem area create an excellent dark contrasting outline of the bands of light minerals (quartz and feldspar). This banding feature is known as foliation. Foliation is a distinquishing characteristic of all gneissic rock.

The granite intrusion of the Canada Hill phase metamorphosed the older existing rocks creating the gneiss which predominates in the subject area.

APPENDIX F

STRUCTURAL GEOLOGY

The Reservoir granite outcropping along Hallenbeck Road is bounded on the north by the Poughquag orthoquartzite and on the south by the Manhattan schist. The boundary with the Manhattan schist is marked by a fault zone in which the schist is down thrust in relation to the granite gneiss. The fault trends in a N 60° E direction and dips 68 degrees to the southeast.

Several shear zones located entirely within the Reservoir granite to the north of the fault generally parallel the strike and dip of the fault plane. Neither the fault nor the shear zones influence the stability of the rock outcrop since the strike of these structures is nearly normal to the face of the outcrop.

The rock outcropping in the problem area is dissected by four major joint sets which comprise the local joint system. The joint sets are described below.

JOINT SET NO. 1 - (Strike N 60° E, Dip - 68° SE)

This joint set are dip joints in that they parallel the foliation inherent in the gneissic structure. It is a compressive joint set related to the forces of local orogeny. Since these joints trend normal to the strike of outcrop, they have very little effect on the rock slope stability. Joint Set No. 1 is designated by the letter "A" on Figure No. 6, Page No. 15.

JOINT SET NO. 2 - (Strike N 10° W, Dip - 48° E)

This joint set is marked by its smooth extended surface, typical of cross joints which are tension related. They are formed roughly at right angles to the flow lines. These joints dip to the east away from the roadway which would normally render them of little consequence to the structural stability of the rock face. However, due to the heavy explosive loadings which were apparently utilized in excavating the rock during the construction of the roadway and railroad beds, the rock at the toe of the slope was badly fractured and ultimately removed during the excavation operation (See Figure No. 9, Page No. 17). This resulted in the creation of a hanging wall effect which allows even the most casual observer to wonder what holds the overhanging mass of rock in place. A similar situation occurs in one location illustrated by two different views, Figures No. 4 and 5, Pages No. 13 and 14. Here the hanging wall effect was created when the blast holes were stemmed (filled with nonexplosive material, probably sand) to a depth of ten to twelve feet below the rock surface. The explosive gases created during the blast detonation escaped through this joint (the upper surface of which remains) thereby reducing the pressure and preventing the fragmentation of the hanging rock area. Joint Set No. 2 is denoted by the letter "B" in the figures mentioned above.

APPENDIX F

STRUCTURAL GEOLOGY

JOINT SET NO. 3 - (Strike N 35° W, Dip - 63° SW)

This joint set formed by shear forces established while the rock mass was under compression. The joint set is marked by steps which range upwards to one foot in height creating an irregular surface. This surface is rarely continuous along its strike for more than five feet. Joint Set No. 3 is most influential in the stability of this rock slope in that it dips toward the roadway. The majority of the rock which was blasted out of this cut moved out from this joint surface. Had this rock cut been presplit on a two vertical on one horizontal (63°) slope; the face would be devoid of unstable rock. This joint set is designated by the letter "C" in Figures No. 6 and 7, Pages No. 15 and 16.

JOINT SET NO. 4 - (Strike N 60° W, Dip - 75° SW)

Joint Set No. 4 is located at the south end of the rock slope just north of the major boundary fault between the Reservoir granite and the Manhattan schist. These joints are known as feather joints which are tension joints whose origin is directly related to faulting. The rock which exists above the location where the joint intersects the rock face presents a very real and impending rockfall hazard. Should the rock in front of this joint surface become dislodged it would cover the road, both tracks and undoubtedly some rock would even reach the river. This area is not located in the original construction blast area. It is a natural unstable rock structure created by the local faulting.

This joint set is designated by the letter "D" on Figures No. 10 and 11 Pages No. 17 and 18.

OTHER JOINTING

Hairline fractures exist throughout the entire rock mass but they are most apparent in the areas where the rock was blasted. It is very difficult to discern the difference between fine tension joints and blasting fractures, however, both are present. They are designated by the letter "E" in Figure No. 5 Page No. 14. Intermittent freeze-thaw cycles in the spring and fall seasons causes minor rock falls in the area. Ultimately large rock falls occur when a keystone is so loosened by frost wedging. It is very possible that the April 2 rock slide originated in this manner.

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